4. Required Modeling Assumptions and Algorithms

Most of the modeling assumptions and algorithms about building operation and climate are either fixed or restricted when an ACM is used for compliance. All approved ACMs must include and automatically use all the appropriate fixed and restricted inputs and calculation methods with no special entry required by the user. Users may not override the fixed inputs when the ACM is used for compliance calculations, nor may they be allowed to go beyond the limitations of the restricted assumptions.

The fixed and restricted modeling assumptions apply to both the *Standard Design* run and to the *Proposed Design* run. The *standard* fixed and restricted modeling assumptions always apply to the *Standard Design* run and are the *default* for the *Proposed Design* run. In some cases, the CEC has approved *alternate* fixed and restricted modeling assumptions that may be used in the *Proposed Design* run. The alternate modeling assumptions may only be used when the *Proposed Design* run has a special building feature (e.g. zonal control) that is recognized as an approved Exceptional Method, and the ACM has been approved with this optional modeling capability. The modeling of such building features for compliance purposes must always be documented as entries in the *Special Features and Modeling Assumptions* listings on the Certificate of Compliance and on the Computer Method Summary.

The following subsections describe the fixed and restricted modeling assumptions or computer inputs and explain how they apply to both the *Standard Design* run and the *Proposed Design* run.

When this manual describes the algorithms and calculational methods used by the reference method, an ACM may use alternative algorithms to calculate the energy use of low-rise residential buildings provided that the algorithms are used consistently for the *Standard Design* and the *Proposed Design* and provided that the ACM passes the applicable tests described in Chapters 5 and 6 and provided that the appropriate input summaries and output information is correctly produced by the ACM. The reference methods of calculation are implemented in the CALRES~~98~~ computer program and used to generate the tests in Chapters 5 and 6.

However, certain algorithms and calculational procedures such as water heating and duct efficiency calculations must be modeled to produce intermediate results precisely and in detail. Typically the tests for these procedures will consist of random testing and result comparison of these intermediate results from a large number of possible tests and conditions.

4.1 Thermostats

Standard Design & ***Proposed Design***: The *standard* thermostat settings are shown in the T~~t~~able 4-1 below. These thermostat setpoints apply to the *Standard Design* run and are the default for the *Proposed Design* run.

Table 4-1 - Thermostat Settings

	Cooling Mode	Heating Mode
Cooling Thermostat	78°F	78°F
Heating Thermostat	60°F	68°F
Heating Setback	60°F	60°F
Ventilation Setpoints	68°F	77°F
Change-over Temperature	60°F	60°F

It is assumed that the building has a constant cooling setpoint of 78°F. When the building is in a heating mode, the heating setpoint is 68°F with night setback to 60°F. The heating thermostat is set back from 11:00 pm until 7:00 am. During the summer or when the building is in a cooling mode, the heating setpoint is a constant 60°F.

The ventilation setpoint is 68°F when the building is in a cooling mode and 77°F when the building is in a heating mode. The state of the building's conditioning mode is dependent upon the outdoor temperature averaged over hours 1 through 24 of day 8 through day 2 prior to the current day. The ACM shall calculate and update daily this seven day running average of outdoor air temperature. When this average temperature is equal to or less than 60°F the building shall be set in a heating mode and all the thermostat setpoints for the heating mode shall apply. When the running average is greater than 60°F the building shall be set to be in a cooling mode and the cooling mode setpoints shall apply.

The standard heating and cooling setpoints are shown in Table 4-2 below for each hour of the day.

Table 4-2 - Standard Thermostat Set Points

Hour	Heating	Cooling	Hour	Heating	Cooling	Hour	Heating	Cooling
1	60	78	9	68	78	17	68	78
2	60	78	10	68	78	18	68	78
3	60	78	11	68	78	19	68	78
4	60	78	12	68	78	20	68	78
5	60	78	13	68	78	21	68	78
6	60	78	14	68	78	22	68	78
7	60	78	15	68	78	23	68	78
8	68	78	16	68	78	24	60	78

Proposed Design: An optional capability, described in Section 6.2, allows alternative thermostat schedules to be used for the *Proposed Design* run when the HVAC system meets the requirements for zonal control. With zonal control, the building is divided into sleeping and living areas and a separate schedule is used for each area. If the user selects this option the ACM shall select the appropriate alternative schedules based on the user's designations for sleeping and living zones and shall automatically report the use of this optional capability in the *Special Features and Modeling Assumptions* listings in the required standard reports.

Certain types of heating and/or cooling equipment are exempt from the mandatory requirement for setback thermostats, including wall furnaces and through-the-wall heat pumps. If setback thermostats are not installed, then the ACM shall model the *Proposed Design* with the standard thermostat schedule, except that the heating mode setback setpoint shall be 66°F instead of 60°F. In cases where setback thermostats are not mandatory but nonetheless are installed by the builder, the ACM shall model the *Proposed Design* using the standard heating setback setpoint of 60°F. The *Standard Design* always assumes the setback schedule shown in Table 4-2.

4.2 R-Value/U-Value Determinations and Calculations

According to the Standards, the R-value of a material is "the [thermal] resistance of a material or building component to the passage of heat in (hr x ft^2 x °F)/Btu."

The R-value indicates how well a material prevents heat from flowing through it. R-19 insulation, for example, is only half as effective at slowing heat transfer as R-38 insulation.

Overall thermal resistances (overall R-values) and overall thermal transmittance values (overall U-value) shall be calculated using algorithms and methods consistent with the algorithms and methods in the 1997 ASHRAE Handbook of Fundamentals, Chapters 22, 23 and 24. For construction assemblies or portions of construction assemblies that consist of two or more plane parallel layers of materials in series (such as exterior siding, insulation and interior gypsum board), the thermal resistance of the assembly is equal to the sum of the individual thermal resistances. When layers are penetrated or interrupted by wood framing or other framing elements that do not readily conduct heat, the parallel path method shall be used to calculate the R-value and U-value of the construction assembly. When metal framing is used or construction layers are penetrated by other significant amounts of highly heat conductive materials such as metals, the zonal calculation method, modified zonal calculation method, finite element or finite difference methods, or the Commission's EZ-frame computer program must be used to determine overall R-value and overall U-value.

Most typical constructions can be calculated using the parallel path method and documented using the residential compliance Form 3R.

The U-value is the inverse of the total R-value:

$$U = 1/R_{Total} \qquad \text{Equation 4.1}$$

The U-value is the heat transfer coefficient expressed in Btu/ft^2-hr-°F, the rate at which heat flows through an assembly or material.

The total R-value shall be entered, displayed, and calculated to at least three significant figures, or, alternatively to two decimal places, and the total U-value to two significant figures or three decimal places whichever is more precise.

4.2.1 Default R-values/U-values in Appendix E

Appendix E contains pre-calculated Form 3Rs for a number of standard assemblies. The Total R-values and U-values from these assemblies must be used in compliance calculations unless a Form 3R is completed for the actual proposed assembly, or unless the compliance approach only uses the insulation level alone. Table E-7 in Appendix E summarizes these default U-values.

Appendix E also includes Form 3Rs for assemblies that meet the default U-values with a combination of batt and rigid insulation, rather than only batt insulation (including metal frame assemblies). In addition, it contains R-values and other information on a variety of masonry wall assemblies.

To determine if an assembly meets the minimum insulation levels required by the mandatory measures or the prescriptive packages, obtain the U-value of the proposed assembly or complete a Form 3R and see if the proposed U-value is less than or equal to the standard U-value for that assembly type and insulation level as listed in Table 3-1 in Chapter 3 and Table E-2 in Appendix E. Compare the proposed U-value to the U-values listed for framing spacing of 16" o.c. for walls and 24".o.c. for roofs/ ceilings.

4.3 Basement Modeling - Basement Walls and Floors

Below grade walls shall have no exterior absorptivity (no radiant gain from sunlight). Below grade walls are modeled with three exterior conditions depending on whether the depth is shallow, medium, or deep.

4.3.1 Shallow Depth Walls

The first two feet (inclusive) of the below grade wall uses the average air temperature for hours 1 through 24 of the 7 days beginning 8 days prior to the current day (days -8 through -2). In addition, a thermal resistance with an R-value of 1.57 (hr.ft^2.^{o}F/Btu) is added between this average temperature and the outside of the below grade wall.

4.3.2 Medium Depth Walls

The basement walls from more than 2 feet below grade through 6 feet below grade have an exterior temperature that is the average of hours 1 though 24 of the 7 days of outdoor temperature from the period starting 68 days prior to the current day being simulated through 62 days prior to the first hour of the current day being simulated. In addition, a thermal resistance with an R-value of 7.28 (hr.ft2.^{o}F/Btu) is added between this lagged average temperature and the outside of the below grade wall.

4.3.3 Deep Walls and Floors

Walls more than 6 feet below grade and basement floors have an exterior temperature that is typical of deep ground temperatures. These temperatures are given in Table 4-3 below for each of the sixteen climate zones. In addition, a thermal resistance with an R-value of 13.7 (hr.ft2.^{o}F/Btu) is added between this average temperature and the outside of the below grade wall. For basement floors this added R-value is 17.6 hr.ft2.^{o}F/Btu.

Table 4-3 Temperatures for Deep Walls and Floors by Climate Zone

Climate Zone	Deep Ground Temperature
1	49.1
2	64.5
3	62.8
4	61.4
5	56.8
6	64.1
7	61.6
8	63.9
9	66.4
10	68.9
11	69.5
12	67.8
13	67.6
14	68.6
15	74.6
16	54.1

4.4 Shading Calculations

4.4.1 Interior Shading and Exterior Sunscreen Operation

Standard Design & ***Proposed Design***: The standard assumptions for operation of interior shading devices and sunscreens shall apply to both the *Standard Design* run and the *Proposed Design* run.

~~Internal shading devices, such as d~~Draperies~~ and blinds,~~ are assumed to be closed only for hours when the air conditioner operates. To approximate this affect during transitions between periods of operation and non-operation, ACMs may assume that the internal device remains closed for the hour following the period of air conditioner operation. As soon as that hour passes, the internal shading device shall be opened. The internal device shall be either totally open or totally closed for any given hour.

External sunscreens are assumed to be in place all year, whether the building is in a heating or cooling mode.

The shading effects of overhangs, side fins and other fixed shading devices are determined hourly based on the altitude and azimuth of the sun for that hour, the orientation of the fenestration, and the relative geometry of the fenestration and the fixed shading devices.

4.4.2 Solar Heat Gain Coefficients

Solar Heat Gain Coefficients shall be determined according to Chapter ~~2 and~~ 3 of this manual. ACMs use two values for setting the Solar Heat Gain Coefficient of shading devices: "$SHGC_{open}$ " and "$SHGC_{closed}$." "$SHGC_{open}$ " applies when the air conditioner is not in operation (off) and "$SHGC_{closed}$ " applies when the air conditioner is in operation. The ACM user shall not be allowed to enter values for $SHGC_{open}$ and $SHGC_{closed}$. These values must be automatically calculated from the specification of the SHGC for the fenestration ($SHGC_{fen}$), the exterior shade and the interior shade as described below. ACMs shall forbid users from direct entry of SHGCs for interior and exterior shading devices. The ACM must automatically determine these values from the user's choices of ~~interior and~~ exterior shading devices and from the assumption that vertical glazing has a drapery and non-vertical (skylight) glazing has no interior shading device.

There are ~~only~~ a limited set of shading devices with fixed prescribed characteristics that are ~~allowed to be~~ modeled in the performance approach. These devices and their associated fixed Solar Heat Gain Coefficients are ~~given~~ listed in ~~Tables 2-1 and 2-2 and are repeated below in~~ Tables ~~4-4~~3-2 and ~~4-5~~3-3. ~~Table 4-4 gives the allowed interior shading devices and Table 4-5 gives the allowed exterior shading devices.~~

~~Table 4-4 Allowed Interior Shading Devices and Recommended Descriptors~~

~~Recommended Descriptor~~	~~Interior Shading Attachment Reference~~	~~Solar Heat Gain Coefficient before 1/1/2002~~	~~Solar Heat Gain Coefficient after 1/1/2002~~
~~*Standard*~~	~~Draperies or No Special Interior Shading -- Default Interior Shade~~	~~0.68~~	~~0.68~~[1]
~~*Blind*~~	~~Venetian Blinds, Vertical Blinds or MiniBlinds~~	~~0.47~~	~~0.47~~
~~*OpRollShd*~~	~~Opaque Roller Shades~~	~~0.47~~	~~0.68~~
~~*None*~~ [2]	~~No Interior Shading - Only for Skylights (Fenestration Tilt < 60 degrees)~~	~~1.00~~	~~1.00~~

~~Note (general): No other interior shading devices or attachments are allowed credit for compliance with the building efficiency standards.~~

~~Note 1: Default drapery shading shall be assumed whenever no other interior shading is specified for a window. Output shall note that although *Standard* is specified, a drapery is modeled but it is not required~~

~~to be installed and present at final inspection. Output shall note for any interior shading device other than drapery that it must be installed and present at final inspection.~~

~~Note 2: *None* is the default for fenestration tilted less than 60 degrees from horizontal (skylights) and is only allowed for fenestration tilted less than 60 degrees from horizontal (skylights)., i.e. *None* is not an interior shading option for ordinary vertical windows.~~

~~Table 4-5 Allowed Exterior Shading Devices and Recommended Descriptors~~

~~Recommended Descriptor~~	~~Exterior Shading Device Reference~~	~~Solar Heat Gain Coefficient~~
~~*BugScrn*~~	~~Bug Screen or No Shading - Default Bug Screens are modeled~~	~~0.76~~
~~*WvnScrn*~~	~~Woven SunScreen (SC<0.35)~~	~~0.30~~
~~*LvrScrn*~~	~~Louvered Sunscreen~~	~~0.27~~
~~*LSASnScrn*~~	~~LSA Sunscreen~~	~~0.13~~
~~*RlDwnAwng*~~	~~Roll-down Awning~~	~~0.13~~
~~*RlDwnBlnds*~~	~~Roll -down Blinds or Slats~~	~~0.13~~
~~*None* [1]~~	~~For skylights only - No exterior shading~~	~~1.00~~

~~Note 1: *None* is the default for fenestration tilted less than 60 degrees from horizontal (skylights) and is only allowed for fenestration tilted less than 60 degrees from horizontal (skylights)., i.e. *None* is not an interior shading option for ordinary vertical windows.~~

The formula for combining Solar Heat Gain Coefficients is:

$$SHGC_{comb} = \left[\left(0.2875 \times SHGC_{\max}\right) + 0.75\right] \times SHGC_{\min}$$

Equation 4.2

Where

$SHGC_{comb}$ = the combined solar heat gain coefficient for a fenestration component and an attachment in series.

$SHGC_{max}$ = the larger of $SHGC_{fen}$ and $SHGC_{dev}$

$SHGC_{min}$ = the smaller of $SHGC_{fen}$ and $SHGC_{dev}$

where

$SHGC_{fen}$ = the Solar Heat Gain Coefficient of the fenestration which includes the window glazing, transparent films and coatings, and the window framing, dividers and muntins,

$SHGC_{dev}$ = the Solar Heat Gain Coefficient of the interior or exterior shading device when used with a metal-framed, single pane window.

For $SHGC_{closed}$, the combination SHGC, $SHGC_{fen+int}$, (the combined SHGC for the fenestration and the interior device) is calculated first and then the combination $SHGC_{fen+int+ext}$ is calculated to determine the overall $SHGC_{closed}$. $SHGC_{open}$ is determined from the combination of $SHGC_{fen}$ and $SHGC_{ext}$.

The combination $SHGC_{fen+int}$ is calculated as above for the *Standard Design* when the Package D specification for SHGC is No Requirement with SHGC = NR (No Requirement) set to a default SHGC of 0.70, which is typical of a double pane, metal-framed window~~ needed to meet the package U-value requirements~~.

$$SHGC_{fen+int} = [(SHGC_{fen} \times 0.2875) + 0.75] \times SHGC_{drap}$$

or

$$SHGC_{fen+int} = [(0.70 \times 0.2875)+0.75] \times 0.68 = [0.95125] \times 0.68 = 0.64685$$

With the effects of the exterior shade,

$$SHGC_{fen+ext} = [(SHGC_{ext} \times 0.2875) + 0.75] \times SHGC_{fen+int}$$

or

$$SHGC_{closed} = SHGC_{fen+int+ext} = [(0.76 \times 0.2875)+0.75] \times 0.64685$$
$$= [0.9685] \times 0.64685 = 0.626$$

and

$$SHGC_{open} = SHGC_{fen+ext} = [(0.76 \times 0.2875)+0.75] \times 0.70$$
$$= [0.9685] \times 0.70 = 0.678$$

4.5 Internal Gains

Standard Design & ***Proposed Design***: Internal gain from lights, appliances, people and other sources shall be set to 20,000 Btu/day for each dwelling unit plus 15 Btu/day for each square foot of conditioned floor area (CFA) as shown in Equation 4.3.

$$IntGain_{total} = (20{,}000xN) + (15x\sum_{i=1}^{N} CFA_i) \qquad \text{Equation 4.3}$$

where

N= number of dwelling units (NumDwellUnits)

CFA_i=Conditioned Floor Area of i^{th} dwelling unit

For addition-alone compliance (single-zone), the gains are apportioned according to the fractional conditioned floor area, referred to as the Fractional Dwelling Unit (FDU). For zone j, the internal gain is determined by Equation 4.4:

$$IntGainZone_j = IntGain_{tot} \times FDU_j$$ Equation 4.4

where

FDU $_j$ = Fractional Dwelling Unit of j[th] zone, calculated from Equation 4.5

$$FDU_j = \frac{CFA_j}{\sum_{i=1}^{N} CFA_i}$$ Equation 4.5

When zonal control is a feature of the *Proposed Design* for a single dwelling unit, the total internal gain is split between the living areas and the sleeping areas as described in Section 6.2.3, pg. 6-4

Building additions may be modeled in conjunction with the existing dwelling or modeled separately (see Sections 6.7.1 and 6.7.2). When modeled together the number of dwelling units for the proposed dwelling ($NDU_{proposed}$) remains equal to the number of dwelling units for the existing structure ($NDU_{existing}$), while the conditioned floor area ($CFA_{proposed}$) is increased to include the contribution of the addition ($CFA_{addition}$). When modeled separately, the internal gain of the addition ($IntGain_{addition}$)is based on the value of the addition's fractional dwelling unit ($FDU_{addition}$), as expressed in Equations 4.6 and 4.7.

Modeling additions is an optional capability described in Section 6.7, Page 6-17.

$$IntGain_{addition} = IntGain_{total} \times FDU_{addition}$$ Equation 4.6

where

$$FDU_{addtion} = \frac{CFA_{addition}}{CFA_{existing} + CFA_{addition}}$$ Equation 4.7

4.6 Internal Gain Schedules

Standard Design & ***Proposed Design***: For hourly computer models, the standard internal gain schedule shown in Table ~~4-~~64 applies. "Hour one" is between midnight and 1:00 am. This schedule shall always be used for the *Standard Design* run. It is the default for the *Proposed Design* run and shall be used unless the *Proposed Design* has zonal control. For zonal control assumptions, see Chapter 6, Section 6.2.

Table 4-4 - Standard Internal Gain Schedule

Hour	Percent	Hour	Percent	Hour	Percent
1	2.4	9	5.6	17	5.7
2	2.2	10	6.0	18	6.4
3	2.1	11	5.9	19	6.4
4	2.1	12	4.6	20	5.2
5	2.1	13	4.5	21	5.0
6	2.6	14	3.0	22	5.5
7	3.8	15	2.8	23	4.4
8	5.9	16	3.1	24	2.7

Daily internal gain shall be modified each month according to the set of multipliers shown in Table 4-~~7~~5. These multipliers are derived from the number of daylight hours each month.

Table 4-5 - Seasonal Internal Gain Multipliers

Month	Multiplier	Month	Multiplier	Month	Multiplier
Jan	1.19	May	0.84	Sep	0.98
Feb	1.11	Jun	0.80	Oct	1.07
Mar	1.02	Jul	0.82	Nov	1.16
Apr	0.93	Aug	0.88	Dec	1.21

4.7 Thermal Mass

Standard Design & ***Proposed Design***: Thermal mass is modeled in both the *Proposed Design* and the *Standard Design*. The modeled mass includes the basic thermal mass such as framing, furniture, 0.5” sheetrock, and household appliances as “light” mass elements and specific “heavy” mass elements such as concrete slab floors. This modeled thermal mass has the ability to store heat and thus damp temperature fluctuations in the conditioned space. The *Proposed Design* and the *Standard Design* must have the same “light” mass elements and for most dwellings the Standard and *Proposed Design*s will also have and model the same “heavy” mass elements.

ACMs must assume that both the *Proposed Design* and *Standard Design* building have a certain amount of minimum “heavy” thermal mass as a function of the conditioned area of slab floor and conditioned nonslab floor. Unless the *Proposed Design* has thermal mass that exceeds a thermal mass minimum threshold, the modeled thermal mass for both the *Proposed Design* and the *Standard Design* is 20% of the *Proposed Design*'s conditioned slab floor area as exposed slab, 80% of the conditioned slab floor area as rug-covered slab, and 5% of the *Proposed Design*’s conditioned nonslab floor area as exposed 2 inch thick concrete.

The modeled exposed slab floor has the following default characteristics: a thickness of 3.5 inches, a volumetric heat capacity of 28 Btu/ft^3-°F, a conductivity of 0.98 Btu-in/hr-ft^2-°F, a surface conductance of 1.3 Btu/hr-ft^2-°F (no thermal resistance on the surface). The remaining 80% of the conditioned slab floor shall be modeled as covered thermal mass with the same characteristics as the exposed mass, but with the addition of a surface R-value of 2.0 (hr-ft^2-°F)/Btu typical of a carpet and pad.

Conditioned nonslab floor area shall be modeled with 5% of the nonslab floor area as exposed thermal mass. This thermal mass is modeled in the *Standard Design* with a thickness of 2.0 inches, a volumetric heat capacity of 28 Btu/ft^3-°F, a conductivity of 0.98 Btu-in/hr-ft^2-°F, a surface conductance of 1.3 Btu/hr-ft^2-°F (no added thermal resistance on the surface). The ACM must also model it this way in the ***Proposed Design*** unless the ***Proposed Design*** exceeds the thermal mass threshold. The ACM may also require that the user specify a "high mass" or "passive solar" option before allowing the entry of special mass elements and the modeling of thermal mass when the total thermal mass exceeds the high mass threshold.

Proposed Design: The *Proposed Design* may model additional thermal mass when the user selects the ACM's "high mass" building input option by modeling thermal mass in excess of the assumed thermal mass for the *Standard Design* when the equivalent design thermal mass for the *Proposed Design* reaches or exceeds a specific mass threshold. This threshold is determined by the amount of thermal mass equivalent to 30% of the conditioned slab floor area as exposed 3.5" thick concrete slab, 70% of the conditioned slab floor area as rug-covered 3.5" thick concrete slab and 15% of the conditioned raised floor area as 2 inch thick exposed concrete with the same specifications as those given above. To determine the threshold, this mass is converted to a standard Interior Mass Capacity using the Unit Interior Mass Capacity (UIMC) method described in Appendix I and compared to the design mass to determine if the mass threshold is exceeded.

4.7.1 Perimeters of Slab Floors and Carpeted Slabs

Standard Design & ***Proposed Design***: For *Standard and Proposed Designs* all ACMs must use slab edge F2 values assuming that 20% of the slab floor perimeter is exposed to the conditioned air and 80% of the slab floor perimeter is carpeted or covered with an R-2 insulating layer between the slab and the conditioned air.

Standard Design: The slab perimeter shall be assumed to have an F2 value based on perimeter insulation as specified for Alternative Component Package D in Section 151 of the building efficiency standards. The Standard Design also assumes that no unconditioned spaces are attached to the conditioned space (in particular that the garage is detached), hence the total slab perimeter length is either insulated or uninsulated per the requirements of Alternative Component Package D. Hence, for the *Standard Design*, the slab edge heat loss factor, F2, is 0.76 for all climate zones except Climate Zone 16 where F2 is 0.51.

Proposed Design: Slab perimeter insulation shall be modeled using an F2 factor for the insulation to be installed and the perimeter length that is to be insulated. The slab perimeter length adjacent to unconditioned spaces such as a garage may be modeled as an R-7 insulated perimeter with an F2 factor of 0.51.

4.8 Solar Gain Targeting

Standard Design & ***Proposed Design***: Solar gains from windows or skylights shall not be targeted to mass elements within the conditioned space of the building. In the reference program, CALRES~~98~~, all solar gain is targeted to the air or a combined air-and lightweight, high surface area mass node within the building. This modeling assumption is used in both the *Standard Design* run and the *Proposed Design* run, except for sunspaces where the user has flexibility in targeting solar gains subject to certain constraints. Sunspace modeling is an optional capability discussed in Section 6.3.

For compliance purposes, when glazing surfaces enclose unconditioned spaces, such as sunspaces, the user is allowed to target all but 25% of the solar gains from these surfaces to mass elements located within the unconditioned space. Unassigned solar gain is targeted to the air or the combined air/lightweight mass or to high surface area lightweight mass in the unconditioned space. At least 25% of the solar gain from any sunspace fenestration surface must be targeted to high surface area lightweight mass and/or the air. At most 60% of the solar gain may be targeted to the slab floor of a sunspace, especially in the summer. For compliance purposes, an ACM must automatically enforce these limits and inform the user of any attempt to exceed these limits.

4.9 Building Heat Capacity

Standard Design & ***Proposed Design***: The heat capacity associated with conventional framed construction includes 1/2 inch gypsum board, wall framing and building contents. The building heat capacity is assumed to be fixed at 3.5 Btu/°F per square foot of conditioned floor area. Other values may be used for unconditioned zones (see Chapter 6).

The assumed value shall apply to the *Standard Design* and shall be the default for the *Proposed Design*.

Proposed Design: The value may be adjusted in the *Proposed Design* run for a user-designated high mass design for special building features such as extra thick gypsum board or heavy mass elements. For such calculations, the surface area of gypsum board shall be assumed to be four times the conditioned floor area. The compliance supplement shall contain recommendations for modifying the building heat capacity, when applicable, and the ACM shall identify the variation in building heat capacity as a special feature of the building. This shall be noted in the "*Special Features and Modeling Assumptions*" listings of the standard reports.

4.10 Standard Weather Data

Standard Design & ***Proposed Design***: All ACMs must use standard weather data for all compliance~~.~~ runs. The standard weather data may be condensed, statistically summarized, or otherwise reduced. However, the basis must be the official Commission's hourly weather data.

The same weather data and weather data format must be used for both the *Standard Design* run and the *Proposed Design* run.

The official hourly weather data for energy compliance is available from the Commission on 1.44 megabyte, 3.5 inch floppy diskettes (IBM-PC format). There are 16 climate zones with a complete year of 8760 hourly weather records. Each climate zone is represented by a particular city. More detail on the weather formats is given in the description package mailed with the weather tapes. The weather data may be obtained by mailing a written request for the weather data, a self-addressed diskette mailer, and three IBM-formatted 1.44 Megabyte diskettes to: RESACM

Weather Data, Residential Office, California Energy Commission, 1516 Ninth Street MS#25, Sacramento, California 95814-5512.

4.11 Ground Reflectivity

Standard Design & ***Proposed Design***: ACMs shall assume that the ground surrounding residential buildings has a reflectivity of 20 percent in both summer and winter. This applies to both the *Standard Design* run and *Proposed Design* run.

4.12 Natural Ventilation

The natural ventilation model is derived from the 1997 *ASHRAE Handbook of Fundamentals*. The model considers both wind effects and stack effects.

- Wind effects include wind speed, prevailing direction and local obstructions, such as nearby buildings or hills.
- Stack effects include the temperature difference between indoor air and outdoor air and the difference in elevation between the air inlet and the outlet.

For compliance purposes, the air outlet is always assumed to be 180 degrees or on the opposite side of the building from the air inlet and the inlet and outlet areas are assumed to be equal. The default inlet area (= outlet area) is five percent of the total window area.

4.12.1 Effective Ventilation Area (EVA)

Both wind and stack driven ventilation depends linearly on the effective ventilation area (EVA). The EVA is a function of the area of the air inlet and the area of the air outlet. For compliance purposes, the default area of air inlet and outlet are both equal to five per cent (half of the total default standard window opening area) of the total window area. For compliance purposes a different window opening areas may be determined from the areas of different window opening types - fixed, sliders, and hinged windows. For research (as opposed to compliance) purposes, inputs for ACMs may enter separate values for inlet and outlet areas. For compliance purposes, the air inlet and the air outlet are each equal to one-half of the *Free Ventilation Area* described in Section 4.13 below.

When the inlet area and outlet area are equal, the EVA is the same, i.e. equal to the inlet area or the outlet area. Hence for compliance purposes the EVA is equal to one-half of the *Free Ventilation Area*.

4.12.2 Stack Driven Ventilation

Stack driven ventilation results when there is an elevation difference between the inlet and the outlet, and when there is a temperature difference between indoor and outdoor conditions.

$$CFM_S = 9.4 \times EVA \times EFF_S \times \sqrt{H \times \Delta T} \qquad \text{Equation 4.8}$$

Where:

CFM_S = Air flow due to stack effects, cfm.

9.4 = Constant from ASHRAE.

EVA = Effective ventilation area as discussed above, sf.

EFF_S = Stack effectiveness.

H = Center-to-center height difference between the air inlet and outlet.

DT = Indoor to outdoor temperature difference, °F.

For compliance purposes the stack effectiveness shall be set at 1.0. The ACM user shall not be permitted to alter this value.

H is the *ventilation height difference*. See Section 4.14 for details.

4.12.3 Wind Driven Ventilation

The general equation for wind driven ventilation is shown below. This equation works in either a direction dependent implementation or a direction independent implementation, as explained later in the text.

$$CFM_w = EVA \times 88 \times MPH \times WF \times EFF_o \times EFF_d \qquad \text{Equation 4.9}$$

Where:

CFM_W = Ventilation due to wind, cfm.

EVA = Effective vent area as discussed above, sf.

88 = A constant that converts wind speed in mph to wind speed in feet per minute.

MPH = Wind speed from the weather tape, mph.

WF = A multiplier that reduces local wind speed due to obstructions such as adjacent buildings.

EFF_O = Effectiveness of opening used to adjust for the location of the opening in the building, e.g. crawl space vents.

EFF_d = Effectiveness that is related to the direction of the wind relative to the inlet surface for each hour.

WF is the *wind correction factor*; this input is fixed at 0.25 for compliance calculations.

The effectiveness of the ventilation opening, EFF_o, is used to account for insect screens and/or other devices that may reduce the effectiveness of the ventilation opening. This input is also used to account for the location of ventilation area, e.g. the exceptional method for two zone crawl space modeling provides for an alternative input for EFF_O. This input is fixed at 1.0 for compliance calculations other than crawlspace modeling.

ASHRAE recommends that the effectiveness of the opening, EFF_d, be set to between 0.50 and 0.60 when the wind direction is perpendicular or normal to the inlet and outlet. A value of 0.25 to 0.35 is recommended for diagonal winds. When the wind direction is parallel to the surface of the inlet and outlet, EFF_d should be zero.

For compliance calculations, the orientation of the inlet and outlet is not considered. ACMs shall assume that the wind angle of incidence at 45 degrees on all windows and only the wind speed dependence is maintained. In this case, the product of EFF_o and EFF_d is equal to 0.28 regardless of the direction of the wind.

4.12.4 Combined Wind and Stack Effects

Stack effects and wind effects are calculated separately and added by quadrature, as shown below. This algorithm always adds the absolute value of the forces; that is, wind ventilation never cancels stack ventilation even though in reality this can happen.

$$CFM_t = \sqrt{CFM_w^2 + CFM_s^2} \qquad \text{Equation 4.10}$$

Where:

CFM_t = Total ventilation rate from both stack and wind effects, cfm.

CFM_w = Ventilation rate from wind effects, cfm.

CFM_s = Ventilation rate from stack effects, cfm.

4.12.5 Determination of Natural Ventilation for Cooling

The value of CFM_t described in Equation 4.10 above gives the maximum potential ventilation when the windows are open. The amount of natural ventilation used by ACMs for natural cooling is the lessor of this maximum potential amount available and the amount needed to drive the interior zone temperature down to the natural cooling setpoint temperature when natural cooling is needed and available. When natural cooling is not needed or is unavailable no natural ventilation is used. ACMs shall assume that natural cooling is needed when the building is in "cooling mode" and when the outside temperature is below the estimated zone temperature and the estimated zone temperature is above the natural cooling setpoint temperature. Only the amount of ventilation required to reduce the zone temperature down to the natural ventilation setpoint temperature is used and the natural ventilation setpoint temperature must be constrained by the ACM to be greater than the heating setpoint temperature.

4.13 Free Ventilation Area

Free ventilation area is the adjusted area taking into account bug screens, window framing and dividers, and other factors.

Standard Design: The *Standard Design* value for free ventilation area is 10% of the fenestration area (rough frame opening). This value is also used for the window Opening Type *Slider*. The approved ACM compliance manual shall note that fenestration-opening type *Slider* also may be selected by the user or automatically used by the ACM as a default or "*Standard*" opening type. This is based upon the assumption that approximately 40% of the rough frame opening is available for ventilation.

Half of this area is considered an air inlet and half an air outlet. This value shall always be used for the *Standard Design* run. It is also the default for the *Proposed Design* run.

Proposed Design: Other values may be used in the *Proposed Design* run only when special windows are installed, high mass is installed, and the "high mass" input option is selected [or the ACM determines that *Proposed Design's* thermal mass exceeds the mass threshold]. The free ventilation area is assumed to be 20% of the fenestration area for hinged type windows such as casements, awnings, hoppers, patio doors and French doors that are capable of a maximum ventilation area of approximately 80% of the rough frame opening. If the ACM user increases the ventilation area for hinged type windows, the ACM must also consider the possible effect of fixed glazing in the building which has no free ventilation area (window opening type *Fixed*). The ACM user may account for additional free ventilation area by entering the total area for sliding windows, the total area for hinged windows, and the total area of fixed windows in the "high mass" menu of the ACM. The ACM must verify that the total area entered for these three types is the same as the total area of windows calculated elsewhere or the ACM may determine the area of fixed windows by subtracting the slider window area and the hinged window area from the total window area if it is less than the total window and skylight area. If the total window and skylight area is less than the area specified for sliding windows and hinged windows the ACM must reduce the area of hinged windows by the difference. The total ventilation area is calculated from the areas of the three possible fenestration opening types, as shown below:

$$Vent_{Area} = (Area_{Slider} \times 0.1) + (Area_{Hinged} \times 0.2) + (Area_{Fixed} \times 0.0) \qquad \text{Equation 4.11}$$

The ACM's ability to accept a customized ventilation area is an optional capability. When this optional capability is used, the fact that the user entered a customized free ventilation area and the total areas of each of these three fenestration opening types must be reported in the *Special Features and Modeling Assumptions* listings on the CF-1R and C-2R. Note that the maximum free ventilation area that may be modeled by any ACM for compliance purposes is 20% of the total area of windows and skylights assuming that all windows and skylights are hinged.

4.14 Ventilation Height Difference

Standard Design: The *Standard Design* modeling assumptions for the elevation difference between the inlet and the outlet is two feet for one story buildings and eight feet for two or more stories.

Proposed Design: For the *Proposed Design* run, the assumption is the same as the *Standard Design* except that greater height differences may be used with special ventilation features such as high, operable clerestory windows. In this case the height difference is the height between the average center height of the lower operable windows and the average center height of the upper operable windows. Such features must be fully documented on the building plans and noted on the ACM standard reports in the *Special Features and Modeling Assumptions* listings as a condition that requires special verification.

4.15 Wind Speed and Direction

Standard Design & ***Proposed Design***: Wind speed affects the infiltration rate and the natural ventilation rate. The infiltration and ventilation rate in the reference method accounts for local site obstructions. For infiltration in the reference method this is done by using Shielding Class 4 coefficients in the Sherman-Grimsrud equation (Section 4.17.1, Equation 4.17) to determine the stack and wind driven infiltration and ventilation. This Shielding Class determination was made on the basis of the description of the Shielding Classes given in the 1997 ASHRAE Handbook of Fundamentals, Table 7, Page 25.22. For Shielding Class 4 the description reads:

> Heavy shielding; obstructions around most of the perimeter, buildings or trees within 30 feet in most directions; typical suburban shielding.

For natural ventilation in the reference method, the wind speed used in calculations is adjusted for differences between the measured wind speed height and the inlet opening height and local obstructions by using a wind factor (WF in Equation 4.9) of 0.25.

4.16 Solar Gain

Solar gain through glazing shall be calculated using the methods documented in the *Algorithms and Assumptions Report, 1988*. This method is modified, however, for the ~~1998~~ standards effective after 1998. Solar gain through windows is reduced to 67.5 percent of the full solar gain and a new algorithm is used to calculate the transmitted solar gain as a function of the angle of incidence on the glazing. The 0.675 reduction is intended to compensate for exterior shading from landscaping, terrain, and adjacent buildings, as well as dirt and other window obstructions.

The formulas used to calculate the solar heat gain through windows as a function of the angle of incidence are given below in the form of two multipliers: - G_{dir} - the ratio of the solar heat gain to the space relative to direct beam insolation at normal incidence, and G_{dif} - the ratio of solar heat gain to the space relative to the diffuse insolation on a horizontal surface. These ratios have no units of measure.

$$G_{dir} = SHGC_{fen} * Area * \left[fsunlit * CosI * P(CosI) + GrndFac \right] \quad \text{Equation 4.12}$$

and

$$G_{dif} = SHGC_{fen} * Area * DMSHGC * \left(vfSky + vfGrnd * GrndRf \right) \quad \text{Equation 4.13}$$

where

$$P(CosI) = C1 * CosI + C2 * Cos^2 I + C3 * Cos^3 I + C4 * Cos^4 I \quad \text{Equation 4.14}$$

$$GrndFac = vfGrnd \times CosG \times GrndRf \times DMSHGC \quad \text{Equation 4.15}$$

$SHGC_{fen}$ = *Fenestration* Solar Heat Gain Coefficient at normal beam incidence - primary user input [unitless]

CosI = The cosine of the angle of incidence of the direct beam insolation on the window. [unitless]

CosG = The cosine of the angle of incidence of the direct beam insolation on the ground. [unitless]

DMSHGC = Diffuse Multiplier for Solar Heat Gain Coefficient [unitless]

fsunlit = fraction of the window sunlit by direct beam at this hour [unitless]

C1, ...,C4	=	polynomial coefficients for angular dependence (cosine of the angle of incidence) of solar heat gain - see Table 4-~~8~~6.
vfSky	=	view factor of window to sky [unitless]
vfGrnd	=	view factor from window to ground [unitless]
GrndRf	=	Ground Reflectance [unitless] = 0.20

Table 4-6 Polynomial Coefficients for Angular Dependence

Glazing Type:	Single Pane (1 light)	More Than One Pane (2 or more lights)
$SHGC_{fen}$	0.860	0.695
C1	3.549794	1.881643
C2	-4.597536	1.014431
C3	2.432124	-4.009235-
C4	-0.384382	2.113160
DMSHGC	0.905814	0.828777

4.17 Infiltration/Ventilation

The effective leakage area method of calculating infiltration for conditioned zones was implemented with the 1992 standards and is still used, but Shielding Class 4 is used for infiltration wind speed reduction, based on the description in the 1997 *ASHRAE Handbook of Fundamentals*.

Effective leakage areas with ACMs is specified in terms of a default specific leakage area of 4.9 for designs with ducted HVAC systems and an SLA of 3.8 for nonducted HVAC systems. These Specific Leakage Areas (SLA) are the defaults for the *Proposed Design* and the assumed standard value for the *Standard Design*. The specific leakage area is the ratio of the effective leakage area to the floor area of the building in the same units. The value is increased by 10,000 to provide a more manageable metric.

$$SLA = \left(\frac{ELA}{CFA}\right)\left(\frac{ft^2}{144in^2}\right)(10000) = \left(\frac{ELA}{CFA}\right)69.444 \qquad \text{Equation 4.16}$$

Where:

ELA = Effective leakage area in square inches

CFA = Conditioned floor area

SLA = Specific leakage area

For both the *Standard Design* and the *Proposed Design*, –ACMs shall assume that occupants will open the windows if the house becomes “too stuffy.” When natural ventilation, infiltration, and mechanical ventilation fall below a threshold value, -the occupants are assumed to open the windows at the beginning of the next hour sufficient to provide an indoor air quality increment which is equal to an additional 0.35 air changes per hour for an eight foot high ceiling. The windows are assumed to remain open and provide this increment of (0.35 air changes per hour) as long as the previous hour’s infiltration, mechanical and natural ventilation rate without this window ventilation for indoor air quality is below the threshold value (see Equations 4.22 through 4.24) Calculation of Infiltration and Ventilation

4.17.1 Calculation of Infiltration and Ventilation

The Effective Leakage Area (ELA) method of calculating infiltration for conditioned zones is documented below and in Chapter 25 of the 1997 ASHRAE Handbook of Fundamentals. The ELA for the *Standard Design* and for the default values for the *Proposed Design* if diagnostic tests are not used, is calculated using the Conditioned Floor Area (CFA) and the Specific Leakage Area (SLA) from Section 4.16 above. (The SLA is the ratio of the effective leakage area to the conditioned floor area of the building, in the same units, multiplied by a factor of 10,000 to provide a more manageable metric.) The energy load on the conditioned space from infiltration heat gains or losses are calculated as follows.

$$CFM_{infil} = ELA \times \sqrt{A \times \Delta T_2 + B \times V^2} \qquad \text{Equation 4.17}$$

$$CFM_{infil+unbalfan} = \sqrt{CFM_{infil}^2 + MECH_{unbal}^2} \qquad \text{Equation 4.18}$$

$$CFM_{infil+totfan} = CFM_{infil+unbalfan} + MECH_{bal} \qquad \text{Equation 4.19}$$

The volumetric air flow (cfm) due to natural ventilation is derived from the natural ventilation cooling for the hour:

$$CFM_{natv} = \frac{Q_{natv}}{1.08 \times \Delta T_1} \qquad \text{Equation 4.20}$$

The total ventilation and infiltration (in cfm) including indoor air quality window operation is:

$$CFM_{total} = CFM_{natv} + CFM_{infil+totfan} + CFM_{iaq} \qquad \text{Equation 4.21}$$

The value of CFM_{iaq} depends on the sum of CFM_{natv} and $CFM_{infil+totfan}$ from the previous time step:

When

$$CFM_{natv} + CFM_{infil+totfan} < \frac{(AFT \times CFA)}{7.5} \qquad \text{Equation 4.22}$$

then

$$CFM_{iaq} = \frac{(0.35 \times CFA)}{7.5} \qquad \text{Equation 4.23}$$

otherwise

$$CFM_{iaq} = 0.000 \qquad \text{Equation 4.24}$$

where

CFA = the total conditioned floor area of the residence

AFT = 0.18 for Climate Zones 2 through 15 inclusive, and;

AFT = 0.25 for Climate Zones 1 and 16.

When the windows are opened they provide a ventilation rate equal to 0.35 air changes per hour for a residence of the same floor area but with eight foot high ceilings. CFM_{iaq} simulates the opening of windows to achieve an acceptable indoor air quality by the occupants when ventilation and infiltration from other sources does not provide an adequate quantity of outdoor air to dilute pollutants and refresh the indoor air.

The energy load on the conditioned space from all infiltration and ventilation heat gains or losses is calculated as follows:

$$Q_{total} = 1.08 \times CFM_{total} \times \Delta T_1 \qquad \text{Equation 4.25}$$

where

Q_{total} = Energy from ventilation and infiltration for current hour (Btu)

CFM_{infil} = Infiltration in cubic feet per minute (cfm)

$CFM_{infil+unbalfan}$ = combined infiltration and unbalanced mechanical ventilation in cubic feet per minute (cfm)

$CFM_{infil+totfan}$ = infiltration plus the balanced and unbalanced mechanical ventilation in cubic feet per minute (cfm)

$MECH_{bal}$ = the balanced mechanical ventilation in cfm. This value is the smaller of the total supply fan cfm and the total exhaust fan cfm.

$MECH_{unbal}$ = the unbalanced mechanical ventilation in cfm. This value is derived from the absolute value of the difference between the total supply fan cfm and the total exhaust fan cfm.

1.08 = conversion factor in (Btu-min)/(hr-ft^3-°F)

ΔT_1 = difference between indoor and outdoor temperature for current hour (°F)

ΔT_2 = difference between indoor and outdoor temperature for previous hour (°F)

A = stack coefficient, (cfm^2/in^4/ F)

B = wind coefficient, (cfm^2/in^4/mph^2)

V = average wind speed for current hour (mph)

ELA= effective leakage area (in^2), measured or calculated using Equation 4.26

The stack (A) and wind (B) coefficients to be used are shown in Table 4-~~9~~7

Table 4-7 - Infiltration Coefficients

	Floor levels		
Coefficient	one	two	three
A (stack)	0.0156	0.0313	0.0471
B (wind) (Shielding Class 4)	0.0039	0.0051	0.0060

The ELA is calculated from the SLA as follows:

$$ELA = CFA \times SLA \times \left(\frac{144\,in^2}{1\,ft^2}\right) \times \left(\frac{1}{10{,}000}\right) \qquad \text{Equation 4.26}$$

where

CFA = conditioned floor area (ft^2)

SLA = specific leakage area (ft^2/ft^2)

ELA = effective leakage area (in^2)

Alternatively, ELA and SLA may be determined from blower door measurements:

$$ELA = 0.055 \times CFM50_H \qquad \text{Equation 4.27}$$

where

$CFM50_H$ = the measured air flow in cubic feet per minute at 50 pascals for the dwelling with air distribution registers unsealed.

Substituting Equation 4.27 into Equation 4.16 gives the relationship of the measured air flow rate to SLA:

$$SLA = 3.819 \times \frac{CFM50_H}{CFA} \qquad \text{Equation 4.28}$$

~~For compliance with the 1998 Standards,~~ ACM users may take credit for reduced infiltration and mechanical ventilation for low-rise, single-family dwellings when verified by site diagnostic testing. ~~For 1998 t~~The model for infiltration ~~has been modified to~~ allows for reduced infiltration entries but also assumes that dwelling occupants will open windows when natural ventilation and infiltration do not provide adequate air quality. When infiltration falls below the threshold described in Equation 4.22, ACMs shall assume that occupants open windows in the next hour and add window ventilation to supplement the infiltration and cooling ventilation to achieve an effective air change rate consistent with ASHRAE Standard 62-1989 as described in Equations 4.20 and 4.21.

The Effective Leakage Area (ELA) of the dwelling may be reduced and the algorithm will result in less energy use due to infiltration unless window ventilation is needed. Lower ELAs will result in more frequent window ventilation and at some point higher energy use. Air quality ventilation may also be added and if this ventilation plus infiltration and cooling ventilation provides adequate air exchange, window ventilation will no longer occur or will occur very infrequently. The energy use of both ventilation exhaust fans and ventilation supply fans must be entered. These ventilation fans are assumed to operate continuously and the energy use of these fans must be included as energy use in the energy budget calculated for the dwelling. Except for the set 0.5 SLA reduction credits, both reduced ELA/SLA and ventilation fans are conditions which require field verification or diagnostic testing by a HERS rater and must be reported in the *HERS Required Verification* listings on the Certificate of Compliance and the Computer Method Summary forms. Controlled ventilation crawl spaces (CVC) and sunspaces are modeled using the air changes per hour method. Modeling of CVC's and sunspaces are optional capabilities covered in Sections 6.1 and 6.3, respectively. All optional capabilities that are used in the *Proposed Design* must be reported in the *Special Features and Modeling Assumptions* listings on the Certificate of Compliance and the Computer Method Summary forms.

4.18 Heating Equipment and Air Distribution Fans

The efficiency of fossil-fuel-fired heating equipment (furnaces, boilers, etc.) is rated as an Annual Fuel Utilization Efficiency (AFUE) ~~with the 1998 standards~~. The test method for calculating AFUE ignores electric energy used by air distribution fans and the contribution of the fan motor input to the heating output. The fan energy is calculated at the rate of 0.005 watt-hours per Btu of heat delivered by the equipment.

The vast majority of residential furnaces have the fan motor in the air stream so the heat generated by the motor contributes to heating the house. This effect may be considered in calculating the source energy for heating.

The heating source energy may be calculated using an effective AFUE which accounts for both the heat contribution of the fan and the source energy used by the fan. The effective AFUE is a similar number to the seasonal efficiency used in pre 1992 ACMs.

$$AFUE_{eff} = \frac{1 + 0.005(3.413)}{\frac{1}{AFUE} + 0.005(10.239)} \qquad \text{Equation 4.29}$$

The effective AFUE is used for all furnaces and boilers that use ducted distribution systems.

4.19 Duct Efficiency

The Commission has approved algorithms and procedures for determining duct and HVAC distribution efficiency. Details are presented in Appendix F.

There are two calculation procedures to determine seasonal air distribution efficiency using either 1) default input assumptions or 2) diagnostic measurement values. Air distribution efficiencies for heating and cooling shall be calculated separately. The ACM shall require the user to choose values for the following parameters to calculate seasonal duct efficiencies as shown below. The ACM shall use the defaults shown in [brackets] for the *Standard Design*~~ and for the *Proposed Design* when the user does not enter a specific value for these parameters or for all proposed designs of dwellings that are not low-rise, single-family dwellings~~[1]. ~~The defaults must also be used for the *Proposed Design* whenever building cavities such as plenums and platform returns are used in lieu of ductwork in some parts of the HVAC air supply or return system~~:

1. Location of the duct system [ducts in the attic]
2. Insulation level of ducts [R 4.2]
3. The surface area of ducts or separate supply and return surface areas ~~for diagnostic verification.~~ [27% of conditioned floor area (CFA) for supply duct surface area; 5% CFA for return duct surface area in single story dwellings and 10% CFA for return duct surface area in dwellings with two or more stories] or the installer measured and HERS rater verified reduced surface area of supply ducts in conjunction with ACCA Manual D design and installer measured and HERS rater verified fan flow consistent with the ACCA Manual D design as specified in 5. below.
4. ~~t~~The leakage level of the duct system [~~22%~~6% of fan flow]. Two values are possible for the proposed design: ~~the default or~~ 6% of fan flow if installer measured and HERS rater verified at no more than 6% of fan flow, otherwise 22% of fan flow shall be used.
5. ACCA manual D design, duct layout and system fan flow [No]. This requires that engineering calculations and a duct layout have been prepared as part of the building plans and that system fan flow specified in those calculations be installer measured and HERS rater ~~diagnostically~~ verified ~~by a HERS rater~~.
6. Designation for systems with less than 12 feet of duct outside conditioned space [No].
7. Attic duct efficiency with radiant barrier in accordance with Package D requirements [Yes in climate zones where required by Package D, otherwise No].

When any duct efficiency credit is claimed beyond the default assumptions that requires diagnostic testing or verification by a HERS rater or the local enforcement agency, i.e. when non-default values (except HVAC equipment capacities) are used to determine duct efficiency, the leaks in the air distribution system connections shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands and this requirement must be specified in the *Special Features and Modeling Assumptions* listings and the *HERS Required Verification* listings on the CF-1R and the C-2R.

The ACM shall automatically use the following values from the description of the *Proposed Design* when calculating the distribution system efficiency:

---

[1] All proposed designs ~~except those using building cavities, such as plenums or platform returns, in lieu of ductwork~~ may model additional insulation (R>4.2) for ducts when installed. The R-value modeled must be the minimum installed insulation level for the entire duct system except as noted in Appendix F even though part of the ducts may serve ~~non~~unmodeled dwellings or spaces.

- Number of stories
- Building Conditioned Floor Area
- Building Volume
- Floor Type
- Presence of attic radiant barrier~~s~~ or cool roof
- Presence of insulation between floor above crawlspace or unconditioned basement, and on or within crawlspace or basement walls adjacent to outside conditions or the ground below
- Outdoor summer and winter design temperatures for each climate zone

When more than one HVAC system serves the building or dwelling, the HVAC distribution efficiency is determined for each system and an conditioned floor area-weighted average seasonal efficiency is determined based on the inputs for each of the systems.

When an existing HVAC system is extended to serve an addition, the default assumptions for duct and HVAC distribution efficiency must be used for both the *Proposed Design* and the *Standard Design*. However, when a new, high efficiency HVAC distribution system is used to serve the addition or the addition and the existing building, that system may be modeled to receive energy credit subject to diagnostic testing and verification of proper installation by a HERS rater.

4.20 Absorptivity

Standard Design: In the *Standard Design* run, the absorptivity of all surfaces is assumed to be the same as the *Proposed Design*.

Proposed Design: In the *Proposed Design*, the absorptivity of walls or other surfaces adjacent to unconditioned spaces, such as crawl space floors and walls adjacent to attached garages, may be assumed to be zero, otherwise all surfaces shall be assumed to have an absorptivity of 0.50.

4.21 Water Heating Calculation Method

This section describes the calculation methods to use with residential water heating systems. The equations listed here must be implemented exactly in general purpose ACMs.

4.21.1 Water Heating Energy Use

The total water heating energy use is the water heating energy use summed over all water heating systems, all water heaters, and all dwelling units being modeled.

$$WHEU_{tot} = \sum_{k=1}^{M} (WHEU_k \times NmbrWHtr_k)$$

Equation 4.30

For the *Proposed Design*, Equation 4.31 applies:

$$WHEU_{proposed} = WHEU_{tot} \; x \; \frac{1000}{CFA_{tot}}$$ Equation 4.31

$$CFA_{tot} = \sum_{i=1}^{N} CFA_i$$ Equation 4.32

$WHEU_{tot}$	=	total water heating energy use
$WHEU_k$	=	water heating energy use for the k^{th} water heating system
$NmbrWHtr_k$	=	number of water heaters in k^{th} water heating system
CFA_i	=	conditioned floor area of the i^{th} dwelling unit (ft^2). The CFA is limited to a maximum of 2,500 ft^2
N =		Number of dwelling units.

4.21.2 Water Heating Energy Budget

The water heating energy budget (WHEB) for a water heating system or a building is determined from the following equation. The budget may be calculated for a system that serves a set of dwelling units or for the entire building. The budget for individual units in a multi-family applications may be expressed as a total, as shown in Equation 4.33.

$$\text{WHEB} = 0.00485 \times \sum_{i=1}^{N} CFA_i + 16.37N$$ Equation 4.33

Where CFAi and N are as described in Section 4.21.1

4.21.3 Water Heating Systems

Water heating distribution systems may serve more than one dwelling unit and may have more than one piece of water heating equipment. The energy used by a water heating system is calculated as the sum of the energy used by each individual water heater in the system. Energy used for the whole building is calculated as the sum of the energy used by each of the water heating systems. To delineate different water heating elements several indices are used.

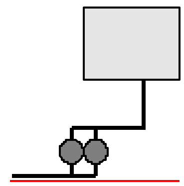
i Used to describe an individual dwelling unit. For instance CFA_i would be the conditioned floor area of the ith dwelling unit. "N" is the total number of dwelling units.

j Used to refer to the number of water heaters in a system. "M" is the total number of water heaters.

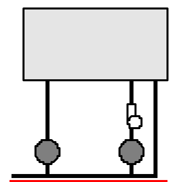
k Used to refer to a water heating system or distribution system. A building can have more than one system and each system can have more than one water heater.

The following diagrams illustrate some of the cases that are recognized by the Commission water heating method.

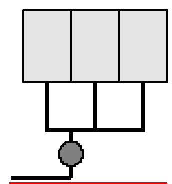
1 One distribution system with two water heaters serving a single dwelling unit.



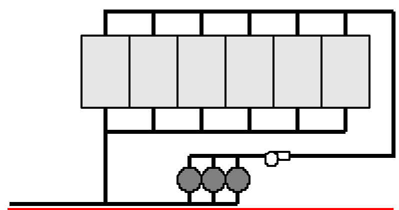
2 Two distribution systems, each with a single water heater serving a single dwelling unit.



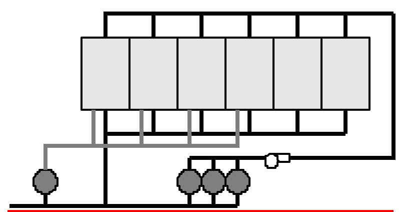
3 One distribution system with one water heater serving multiple dwelling units.



4 Single distribution system with multiple water heaters serving multiple units.



5 Two distribution systems, one with multiple water heaters serving multiple dwelling units. The recirculating distribution system serves all the units. The other serves only four units.



The following rules apply to the calculation of water heating system energy use:

- 1 water heater type per system
- 1 solar or woodstove credit (but not both) per system

4.21.4 Adjusted Recovery Load (ARL)

The adjusted recovery load is calculated separately for each water heating distribution system, *k*. It accounts for the number of units served, the size of each unit and the type of distribution system. ARL_k is given by the following equations for the kth distribution system.

$$ARL_k = SRL_k \, DSM_k \, SSM_k \qquad \text{Equation 4.34}$$

Where

SRL_k = Standard water heating recovery load of the kth water heating distribution system (million Btu/yr).

DSM_k = Distribution system multiplier (unitless) for the kth water heating system. A value of one is used for standard distribution systems. (See Table 4-~~10~~8)

SSM_k = Solar savings multiplier (unitless) for the kth water heating system. See equation below.

$$SSM_k = 1 - (SSF_k\, A) \qquad \text{Equation 4.35}$$

SSF_k = Solar savings fraction taken from an f-Chart analysis or other approved method (unitless).

A = Adjustment to the SSF (unitless). This value is 0.80 to account for pumping energy and piping heat loss effects when these losses are not accounted for in the f-Chart analysis and 1.00 for passive systems (no circulation pump) and systems where pump energy and piping losses were included in the f-Chart analysis. (Piping loss effects are accounted for in the Commission Passive Solar Credit calculation procedure). Approved ACM compliance supplements shall state that pipe losses are not to be accounted for in the f-Chart analysis of active solar water heating systems.

When a water heating system has more than one water heater, the total load on the system is assumed to be shared equally by each water heater. The ARL for the jth water heater is then shown in the following equation.

$$ARL_j = \frac{ARL_k}{NmbrEquip_k} \qquad \text{Equation 4.36}$$

Where

$NmbrEquip_k$ = The number of water heaters in the kth system.

4.21.4.1 Standard Recovery Load

The standard water heating recovery load for the kth system is the load assuming a standard distribution system and no solar or wood stove credits. It depends on the size of the dwellings and number of units and is given in the following equation (million Btu/yr).

$$SRL_k = \sum_{i=1}^{n} \frac{0.0855347\left(\frac{CFA_i}{1000}\right)^2 + 3.61307\left(\frac{CFA_i}{1000}\right) + 6.036}{NmbrSys_i} \qquad \text{Equation 4.37}$$

Where

CFAi = Conditioned floor area of the ith dwelling unit served by the water heater (ft^2). The CFA is limited to a maximum of 2,500 ft^2 per dwelling unit.

n = Number of dwelling units served by the kth water heating system.

$NmbrSys_i$ = Number of water heating systems that serve the ith dwelling unit. When a dwelling unit is served by more than one system, the assumption is that the load is shared equally by each system.

4.21.4.2 Distribution System Multiplier

The distribution system multiplier (unitless) is an adjustment for alternative water heating distribution systems. A value of one is used for standard distribution systems. Values for other systems are given in the following table

Table 4-8 - Distribution System Multipliers (DSMs)

Distribution System	COEF	DSM - Single Family	DSM-MultiFamily
Standard	-2.56	1.00	1.00
POU	-0.51	0.82	na
HWR	-0.51	0.82	na
Pipe Insulation	-1.72	0.92	0.92
Parallel Piping	-0.96	0.86	0.86
Recirc/NoControl	-8.39	1.52	1.52
Recirc/Timer	-5.64	1.28	na
Recirc/Temp	-3.14	1.05	1.05
Recirc/Demand	-2.37	0.98	na
Recirc/Time+Temp	-2.14	0.96	na
Recirc/Demand + HWR	-2.37	0.80	na
Recirc/Demand + Pipe Insulation	-2.37	0.90	na

4.21.5 Energy Use of Individual Water Heaters

Once the adjusted recovery load is determined for each water heater, the energy use for each water heater is calculated as described below for each water heater type.

4.21.5.1 Storage Gas, Storage Electric and Heat Pump Water Heaters

The energy use of storage gas, storage electric and heat pump water heaters is given by the following equation.

$$WHEU_j = \left[\frac{ARL_j \times HPAF_j}{LDEF_j} \right] WSAF_j \qquad \text{Equation 4.38}$$

Where

$WHEU_j$ = Energy use of the water heater (millions Btu/yr), adjusted for tank insulation and wood stove boilers.

ARL_j = Adjusted recovery load (millions Btu/yr). Equations for this value are given in Section 4.21.4.

SEM_j = Source energy multiplier (unitless). This multiplier is 3.0 for electric and heat pump water heaters and 1.0 for gas or oil water heaters.

$HPAF_j$ = Heat pump adjustment factor from the table below based on climate zone. This value is one for storage gas, storage oil and storage electric water heaters.

Table 4-9 - Heat Pump Adjustment Factors

Climate Zone	Heat Pump Adjustment Factor	Climate Zone	Heat Pump Adjustment Factor
1	1.040	9	0.920
2	0.990	10	0.920
3	0.990	11	0.920
4	1.070	12	1.070
5	1.070	13	0.920
6	0.920	14	1.040
7	0.920	15	0.920
8	0.920	16	1.500

$LDEF_j$ = The load dependent energy factor (LDEF) is given by the following equation. This equation adjusts the standard EF for different load conditions.

$$LDEF_j = \ln\left(\frac{ARL_j \times 1000}{365}\right)\left(a \times EF_j + b\right) + \left(c \times EF_j + d\right)$$ Equation 4.39

a,b,c,d = Coefficients from the table below based on the water heater type.

Table 4-10 - LDEF Coefficients

Coefficient	Storage Gas	Storage Electric	Heat Pump
A	-0.098311	-0.91263	0.44189
B	0.240182	0.94278	-0.28361
C	1.356491	4.31687	-0.71673
D	-0.872446	-3.42732	1.13480

EF_j = Energy factor of the water heater (unitless). This is based on the DOE test procedure.

$WSAF_k$ = Wood stove boiler adjustment factor for the kth water heating system. This is given in Section ~~0~~4.21.5.5. This is an optional capability and is set to 1.00 for ACMs without wood stove boiler modeling capability.

4.21.5.2 Instantaneous Gas or Oil

The energy use for instantaneous gas or oil water heaters is given by the following equation.

$$WHEU_j = \left[\frac{ARL_j \times SEM_j}{EF_j} + \frac{PILOT_j \times 8760}{1000000}\right] WSAF_j$$ Equation 4.40

Where

ARL_j = Adjusted recovery load from Section 4.21.4..

SEM_j = Source energy multiplier (unitless). This multiplier is 1.0 for gas or oil water heaters and can therefore be ignored.

EF_j = Energy factor from the DOE test procedure (unitless). This is taken from manufacturers literature or from the CEC Appliance Database.

$PILOT_j$ = Energy consumption of the pilot light (Btu/h).

$WSAF_k$ = Wood stove boiler adjustment factor for the kth water heating system. This is given in Section ~~0~~4.21.5.5. This is an optional capability and is set to 1.00 for ACMs without wood stove boiler modeling capability.

4.21.5.3 Instantaneous Electric

Energy use for instantaneous electric water heaters is given by the following equation.

$$WHEU_j = \left[\frac{ARL_j \times SEM_j}{EF_j}\right] WSAF_j \qquad \text{Equation 4.41}$$

ARL_j = Adjusted recovery load from Section 4.21.4.

SEM_j = Source energy multiplier (unitless). This multiplier is 3.0 for electric water heaters.

EF_j = Energy factor from DOE test procedure (unitless).

$WSAF_k$ = Wood stove boiler adjustment factor for the kth water heating system. This is given in Section 0. This is an optional capability and is set to 1.00 for ACMs without wood stove boiler modeling capability.

4.21.5.4 Large storage gas and Indirect Gas

Energy use for large storage gas and indirect gas water heaters is given by the following equation. Note: large storage gas water heaters are defined as any gas storage water heater with an input rate not less than 75,000 Btu/h.

$$WHEU_j = \left[\frac{ARL_j + (JL_j)}{EFF_j \times EAF_j} + PILOT_j\left(\frac{8760}{1000000}\right)\right] WSAF_j \qquad \text{Equation 4.42}$$

[SBL_j has been deleted from this equation]

Where

ARL_j = Adjusted recovery load (defined later).

JLj= Jacket loss (millions Btu/yr). Equations are given in Section 4.21.7.

EFF_j = Efficiency (fraction, not %). To be taken from CEC Appliance Database or from manufacturers literature. These products may be rated as a recovery efficiency, thermal efficiency or AFUE.

EAF_j = Efficiency adjustment factor (unitless). This value is 1.0 for large storage gas water heaters and 0.98 for indirect gas water heaters.

$PILOT_j$ = Pilot light energy (Btu/h).

$WSAF_k$ = Wood stove boiler adjustment factor for the kth water heating system. This is given in Section ~~0~~4.21.5.5. This is an optional capability and is set to 1.00 for ACMs without wood stove boiler modeling capability.

4.21.5.5 Wood Stove Adjustment Factors

This is an optional capability and the Wood Stove Boiler Adjustment Factor is set to 1.00 for ACMs without wood stove boiler modeling capability. The wood stove adjustment factor (unitless) reduces water heating energy to account for the heat contribution of wood stove boilers. This multiplier is taken from the table below, based on climate zone and whether or not the wood stove boiler has a recirculation pump. The inclusion of this factor and its relevant input parameters is an optional capability for ACMs. However, when this optional capability is implemented the algorithms and procedures given below must be used.

Table 4- 11 - Wood Stove Adjustment Factors

Climate Zone	Wood Stoves with Pumps	Wood Stoves without Pumps
1	0.775	0.750
2	0.775	0.750
3	0.775	0.750
4	0.865	0.850
5	0.865	0.850
6	0.910	0.900
7	0.910	0.900
8	0.955	0.950
9	0.910	0.900
10	0.955	0.950
11	0.910	0.900
12	0.865	0.850
13	0.910	0.900
14	0.910	0.900
15	1.000	1.000
16	0.730	0.700

4.21.6 Tank Surface Area

Tank surface area (TSA) is used to calculate the jacket loss (JL) for large storage gas and indirect gas water heaters. TSA is given in the following equation as a function of the tank volume.

$$TSA_j = e\,(f\ VOL_j^{0.33} + g)^2 \qquad \text{Equation 4.43}$$

Where

VOL_j = Actual tank capacity (gallons).

e,f,g = Coefficients given in the following table.

Table 4-12 - Coefficients for Calculating Tank Surface Areas

Coefficient	Storage Gas	Large Storage Gas and Indirect Gas	Storage Electric and Heat Pumps
e	0.00793	0.01130	0.01010
f	15.67	11.8	11.8
g	1.9	5.0	5.0

4.21.7 Jacket Loss

The jacket loss for large storage gas and indirect gas water heaters

$$JL_j = \left(\frac{TSA_j(135-60.3)}{RTI_j + REI_j} + (FTL_j)(EFF_j)(EAF_j) \right)\left(\frac{8760}{1000000} \right) \qquad \text{Equation 4.44}$$

Where

TSA_j = Tank surface area (ft[2]).

FTL_j = Fitting losses[2]. This is a constant 61.4 Btu/h.

REI_j = R-value of exterior insulating wrap.

$$RTI_j = \left(\frac{TSA_j(135-60.3)}{(8.345(VOL_j)(SBL_j)(135-60.3) - FTL_j - PILOT_j)(EFF_j)(EAF_j)} \right) \qquad \text{Equation 4.45}$$

SBLj = Standby loss expressed as a fraction of the heat content of the stored water lost per hour from the CEC Appliance Database or from manufacturer's literature.

Where EFF_j and EAF_j are efficiencies as described in *Section 4.21.5.4*

4.22 Slab Heat Loss (F2 Factor)

See Section 4.7.1.

2 See Davis Energy Group report, Section III, Page A-8.

4.23 Fenestration Products

Information concerning fenestration products, specifically the default table for fenestration U-values and the default table for fenestration SHGC values, is included in Sections 101 and 116 of Title 24, Part 6, the energy efficiency standards for buildings.

4.24 Radiant Barriers

Standard Design: The *Standard Design* ~~does not have or use~~ has a radiant barrier~~s~~ in accordance with Package D requirements.

Proposed Design: ~~Energy credit for radiant barriers may be used with approved 1998 alternative calculation methods (ACMs). Approved ACMs must be able to model radiant barriers. The reference method models r~~Radiant barriers are modeled by calculating ceiling U-value modifiers that are functions of the ceiling insulation and the season and by using different seasonal attic temperatures for attics with radiant barriers which result in better HVAC distribution efficiencies for ducts in the attic below a radiant barrier.

Radiant barriers must meet specific eligibility and installation criteria to be modeled by any ACM and receive energy credit for compliance with the energy efficiency standards for low-rise residential buildings.

- The ~~emissivity~~ emittance of the radiant barrier must be less than or equal to 0.05 as tested in accordance with ASTM ~~Test Method~~ C-1371-9~~7~~8 or ASTM E408-71(1996)e1.
- Installation must be in conformance with ASTM C-1158-97 (Standard Practice For Use and Installation Of Radiant Barrier Systems (RBS) In Building Construction.), ASTM C-727-90(1996)e1 (Standard Practice For Installation and Use Of Reflective Insulation In Building Constructions.), ASTM C1313-97~~5~~ (Standard Specification for Sheet Radiant Barriers for Building Construction Applications), and ASTM C-1224-99~~3~~ (Standard Specification for Reflective Insulation for Building Applications) and the radiant barrier must be securely installed in a permanent manner with the shiny side facing down toward the attic floor. Moreover, radiant barriers must be installed to the roof truss/rafters (top chords) in ***any*** of the following methods, with the material:
    1. Draped over the truss/rafter (the top chords) before the upper roof decking is installed.
    2. Spanning between the truss/rafters (top chords) and secured (stapled) to each side.
    3. Secured (stapled) to the bottom surface of the truss/rafter (top chord). A minimum air space must be maintained between the top surface of the radiant barrier and roof decking of not less than 1.5 inches at the center of the truss/rafter span.
    4. Attached [laminated] directly to the underside of the roof decking. The radiant barrier must be laminated and perforated by the manufacturer to allow moisture/vapor transfer through the roof deck.

  In addition, the radiant barrier must be installed to cover all gable end walls and other vertical surfaces in the attic.
- The attic must be ventilated to:

1. conform to manufacturer's instructions.
2. provide a minimum free ventilation area of not less than one square foot of vent area for each 150 square feet of attic floor area.
3. provide no less than 30 percent upper vents.
4. ~~have a minimum gap of 3.5 inches between the bottom of the radiant barrier and the top of the ceiling insulation to allow ventilation air to flow between the roof decking and the top surface of the radiant barrier (except for method 4 above).~~
5. ~~have a minimum of six (6) inches (measured horizontally) left at the roof peak to allow hot air to escape from the air space between the roof decking and the top surface of the radiant barrier (except for method 4 above).~~

(Ridge vents or gable end vents are recommended to achieve the best performance. The material should be cut to allow for full air flow to the venting.)

- The radiant barrier (except for radiant barriers laminated directly to the roof deck) must be installed to:
  1. have a minimum gap of 3.5 inches between the bottom of the radiant barrier and the top of the ceiling insulation to allow ventilation air to flow between the roof decking and the top surface of the radiant barrier ~~(except for method 4 above).~~
  2. have a minimum of six (6) inches (measured horizontally) left at the roof peak to allow hot air to escape from the air space between the roof decking and the top surface of the radiant barrier ~~(except for method 4 above)~~.
- When installed in enclosed rafter spaces where ceilings are applied directly to the underside of roof rafters, a minimum air space of 1 inch must be provided between the radiant barrier and the top of the ceiling insulation, and ventilation must be provided for every rafter space. Vents must be provided at both the upper and lower ends of the enclosed rafter space.
- The product must meet all requirements for California certified insulation materials [radiant barriers] of the Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, as specified by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material ~~as indicated in the *Consumer Guide and Directory of Certified Insulation Products*~~.

The use of a radiant barrier and the criteria specified above for covering all gable end walls and other vertical surfaces in the attic, and for providing attic ventilation shall be listed in the *Special Features and Modeling Assumptions* listings of the CF-1R and C-2R and described in detail in the ACM Compliance Supplement.

For the heating season, Equation 4.46 is the expression for the U-value modifier; for the cooling season, Equation 4.47. To determine the U-value for a ceiling with a radiant barrier, multiply the U-value of the ceiling assembly without the radiant barrier times the U-value modifier. The U-value modifiers are calculated from equations 4.46 and 4.47.

For installed insulation greater than R-8:

$$UvalMod_{heating} = (-11.404 \times U^2) + (0.21737 \times U) + 0.92661 \qquad \text{Equation 4.46}$$

$$UvalMod_{cooling} = (-58.511 \times U^2) + (3.22249 \times U) + 0.64768 \qquad \text{Equation 4.47}$$

Otherwise these modifiers are 1.000.

4.25 Cool Roofs

Standard Design: The *Standard Design* does not have a cool roof.

Proposed Design: Cool roofs are assumed to have an impact equal to the cooling savings for radiant barriers. The calculations are the same as described in section 4.24 except that $UvalMod_{heating}$ (equation 4.26) is assigned a value of 1.0. In the event that both a cool roof and radiant barrier is specified, there is no credit for the cool roof.

Cool roofs must meet specific eligibility and installation criteria to receive energy credit for compliance as described in the standards and this section. In general, the solar reflectance must be 0.4 or higher for tile roofs or 0.7 or higher the other roof materials; and the emittance must be 0.75 or higher. The use of a cool roof shall be listed in the *Special Features and Modeling Assumptions* listings of the CF-1R and C-2R and described in detail in the ACM Compliance Supplement.

Liquid applied roofing products shall be applied at a minimum dry mil thickness of 20 mils across the entire roof surface, and meet the minimum performance requirements of ASTM D6083-97a when tested in accordance with ASTM D6083-97a for the following key properties:

* Initial Tensile Strength
* Initial Elongation
* Elongation After 1000 Hours Accelerated Weathering
* Permeance
* Accelerated Weathering

Effective January 1, 2003, all products qualifying for this credit will be required to meet the Cool Roof Rating Council testing, certification and labeling requirements described in Section 10-113 of the standards. Prior to January 1, 2003, the solar reflectance shall be measured in accordance with ASTM E1918-97 or ASTM E903-96. Emittance shall be measured in accordance with ASTM E408-71(1996)e1. The solar reflectance and emittance shall be certified by the manufacturer and reported in product literature.

4.2~~5~~6 No Cooling

Standard Design: The *Standard Design* has a cooling system as described in Section 3.8.2. for a central ducted cooling system~~s~~ the same as the *Proposed Design*.

Proposed Design: Where no air conditioning system is proposed for use, the *Proposed Design* is required to model a split system air conditioner with an SEER of 10.0 with R-4.2 ducts located in the attic with *Standard Design* default duct characteristics and a thermostatic expansion valve in accordance with Package D.

4.2~~6~~7 Commission Equivalent Efficiencies

The approved ACM compliance supplement must include the following conversion~~s~~ and substitution:

For equipment without an HSPF rating, the HSPF may be calculated as:

- HSPF = (3.2 x COP) - 2.4 Equation 4.48
- The EER may be used in lieu of the SEER for equipment not required to be tested for an SEER rating.